

GALACTIC DISTRIBUTION OF ECLIPSING BINARIES
AND ITS SIGNIFICANCE

by

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ABSTRACT

From the galactic distribution of eclipsing binaries, it follows that the angular momenta associated with orbital motion of close binaries are not due to localization of galactic rotation of pre-stellar media. Hence, we may expect a general random orientation of orbital planes in space, although this expectation may not be true for a single group of stars.

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In order to understand star formation, perhaps the origin of stellar angular momentum provides one of the important clues. Binaries, rotating stars and planetary systems all have high angular momenta. Where do these angular momenta come from? We might conceive that they come from the localization of galactic rotation of the pre-stellar medium.

Equally, we might consider them as resulting from the random motion of different parts of the pre-stellar medium. In the first case, the stellar momentum vectors would always be perpendicular (or nearly perpendicular) to the galactic plane. In the second case, the stellar angular momentum vectors will be oriented in space at random. Statistical studies of orientation of orbital planes of visual binaries (Chang 1929, Finsen 1933) shows that the second is the actual case. Statistical results of stellar rotation appear also to contradict the first possibility and finds no inconsistency with the second possibility (Struve 1945, Huang and Struve 1956). In the present note, the orientation of orbital planes of eclipsing binaries with respect to the galactic plane will be examined with a view to see once more which one of the two cases disagrees with observational results.

From the "Finding List for Observers of Eclipsing Variables" compiled by Kock, Sobieski and Wood (1963), we have made a statistical study of their distribution with respect to the galactic coordinate system II (using as the 1900.0 position of the galactic pole $R.A. = 12^h 46^m.6$ and $Dec. = 27^\circ 40' 0''$). The list covers eclipsing binaries of the entire sky down to the 13th magnitude at minimum light. Three post novae in the list which do not satisfy this criterion are excluded from this consideration. Hence, altogether there are 1263 systems for this study.

Tables 1 and 2 give the numbers and densities per square degree of eclipsing binaries in different galactic latitude and longitude zones. If the stellar angular momentum should

be derived from galactic rotation, all orbital planes would be parallel to the galactic plane. Being located in the galactic plane ourselves, we would then find eclipsing binaries only near the galactic equator, say between $b = -15^\circ$ and $b = 15^\circ$. It is obvious from Table 1 that the eclipsing binaries are not limited only to the low galactic latitudes between -15° and 15° as would be expected from the hypothesis of galactic rotational origin. In the hemisphere north of the galactic equator there are 181 eclipsing systems between $b = 0^\circ$ and $b = 15^\circ$ in a total of 627. In the hemisphere south of the galactic equator there are 187 systems between $b = 0^\circ$ and $b = -15^\circ$ in a total of 636. Hence, more than two thirds of the systems are located at galactic latitudes higher than fifteen degrees. This rules out the galactic rotational origin of stellar angular momentum. That the table shows low density of eclipsing binaries in the very high galactic latitudes perhaps reflects only the trend resulting from the galactic concentration of stars in general.

Also to be noted is the fact that the inclination of the orbital plane of an eclipsing binary at galactic latitude b with the galactic plane can assume any value from b to $\pi/2$, as we can easily see from a simple geometry of eclipse. Hence, orbital planes of eclipsing binaries found in high latitudes have necessarily large inclinations with respect to the galactic plane while those found in low latitudes may have either large or small inclinations.

We also note in the tables some peak distributions in the number per square degree in two latitude zones (-30° to -25° and 25° - 30°) as well as large fluctuations in the longitude zones. The comparatively low surface star densities in the latitude zones between the two peak distributions could be due to galactic obscuration which cuts down the number of eclipsing binaries so far detected. It may also suggest that there is some local correlation in the angular momentum

vectors of binaries. In other words, in a group of binaries there might be a statistically preferential orientation of the orbital planes. In this respect we should recall the discovery by Batten (1960) that some sort of relationship exists between similar binary systems. He cites the fact that of 12 eclipsing systems with supergiant components, 6 lie within about 3° on the celestial sphere. The significance, if any, of Batten's finding and the slight clustering of eclipsing binaries in the latitude and longitude zones found here remains obscure. Also to be mentioned in this connection is the behavior of stellar rotation in clusters. In some clusters, like the Pleiades, stars appear to rotate faster than the field stars of the same spectral types (Struve 1945). This has been often attributed to systematic high rotational velocities in the cluster. However, from what has just been said about possible weak alignment of orbital planes of close binaries in a group, the rotational behavior of stars in the Pleiades may be interpreted by a somewhat preferred orientation of equatorial planes of rotating stars which make statistically larger angles of inclination with the celestial sphere for all stars in the cluster than would be expected from random orientation of their spinning axes. Finally, the large fluctuation in the distribution of eclipsing binaries over the sky may show the intrinsic large fluctuations of close binaries in space. For example, the number of binaries in the Pleiades is much less than the value expected from the over-all average of their frequency occurrence.

Finally, let us consider the angular momentum vector of the planetary system. It is defined by the invariable plane of the system. The pole of this plane is located at the galactic latitude of 28° indicating that the invariable plane making an angle of 62° with the galactic plane. This shows that the angular momentum of our own planetary system did not come from galactic rotation.

All these investigations from visual binaries to our own planetary system agree in one point, i.e., stellar angular momentum is not derived from galactic rotation. However, we should realize that a free condensation of tenuous gas that

shares galactic rotation in interstellar space is inevitably accompanied by localization of a large amount of galactic angular momentum (e.g. Edgeworth 1946). Thus, we face the contradiction between the indisputable result of observation and the inevitable consequence of theoretical deduction. Perhaps in resolving this difficulty we may find an important clue of star formation. Tentatively, we see two possibilities which are not mutually exclusive to reconcile the observed fact and theoretical prediction. Perhaps the angular momentum associated with random motion is much larger than that associated with differential galactic rotation. This situation may be realized if stars are formed as a group (Roberts 1957). The angular momentum of the pre-stellar medium arising from galactic rotation is preserved in the relative motions among the stars themselves. But the angular momentum associated with axial rotation and orbital motion of binary systems depends only upon the local fluctuation, say due to local turbulent velocity field in the pre-stellar medium. Since formation of stars is a purely local phenomenon the stellar angular momentum vector either is randomly oriented in space or shows some slight preference in orientation characteristic again of the local fluctuation alone. The other possibility is that in the process of condensation little angular momentum of galactic rotation is localized. This would be the case if either the condensation follows the "stream lines" of galactic rotation (one-dimensional collapse) or there is a strong interaction between the condensing material and interstellar magnetic field so that the localized angular momentum is dissipated by electromagnetic interaction before the material is fragmented into stellar masses.

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TABLE 1

DISTRIBUTION OF ECLIPSING BINARIES
IN GALACTIC LATITUDE ZONES

| Latitude Zone | No. | Surface Density No./sq. Degree | Latitude Zone | No. | Surface Density No./sq. Degree |
|---------------|-----|-----------------------------------|---------------|-----|-----------------------------------|
| 0 - 5° | 63 | .035 | 0 - -5° | 66 | .036 |
| 5° - 10° | 57 | .032 | -5° - -10° | 56 | .031 |
| 10° - 15° | 61 | .035 | -10° - -15° | 65 | .037 |
| 15° - 20° | 54 | .031 | -15° - -20° | 62 | .036 |
| 20° - 25° | 64 | .038 | -20° - -25° | 61 | .037 |
| 25° - 30° | 85 | .053 | -25° - -30° | 139 | .087 |
| 30° - 35° | 79 | .052 | -30° - -35° | 66 | .043 |
| 35° - 40° | 52 | .036 | -35° - -40° | 32 | .022 |
| 40° - 45° | 28 | .021 | -40° - -45° | 21 | .016 |
| 45° - 50° | 21 | .017 | -45° - -50° | 15 | .012 |
| 50° - 55° | 23 | .021 | -50° - -55° | 14 | .013 |
| 55° - 60° | 8 | .008 | -55° - -60° | 12 | .012 |
| 60° - 65° | 15 | .018 | -60° - -65° | 7 | .008 |
| 65° - 70° | 5 | .007 | -65° - -70° | 12 | .017 |
| 70° - 75° | 7 | .013 | -70° - -75° | 3 | .006 |
| 75° - 80° | 4 | .010 | -75° - -80° | 5 | .013 |
| 80° - 85° | 1 | .004 | -80° - -85° | 0 | 0 |
| 85° - 90° | 0 | 0 | -85° - -90° | 0 | 0 |

TABLE 2

DISTRIBUTION OF ECLIPSING BINARIES
IN GALACTIC LONGITUDE ZONES

| Longitude Zone | No. | Surface Density No./sq. Degree | Longitude Zone | No. | Surface Density No./sq. Degree |
|----------------|-----|-----------------------------------|----------------|-----|-----------------------------------|
| 0° - 10° | 25 | .022 | 180°-190° | 45 | .039 |
| 10° - 20° | 35 | .031 | 190°-200° | 50 | .044 |
| 20° - 30° | 41 | .036 | 200°-210° | 35 | .031 |
| 30° - 40° | 42 | .037 | 210°-220° | 29 | .025 |
| 40° - 50° | 30 | .026 | 220°-230° | 35 | .031 |
| 50° - 60° | 38 | .033 | 230°-240° | 29 | .025 |
| 60° - 70° | 44 | .038 | 240°-250° | 48 | .042 |
| 70° - 80° | 32 | .028 | 250°-260° | 37 | .032 |
| 80° - 90° | 21 | .018 | 260°-270° | 36 | .031 |
| 90°-100° | 19 | .017 | 270°-280° | 33 | .029 |
| 100°-110° | 25 | .022 | 280°-290° | 25 | .022 |
| 110°-120° | 32 | .023 | 290°-300° | 31 | .027 |
| 120°-130° | 44 | .038 | 300°-310° | 60 | .052 |
| 130°-140° | 40 | .035 | 310°-320° | 55 | .048 |
| 140°-150° | 31 | .027 | 320°-330° | 18 | .016 |
| 150°-160° | 33 | .029 | 330°-340° | 20 | .017 |
| 160°-170° | 40 | .035 | 340°-350° | 27 | .024 |
| 170°-180° | 65 | .057 | 350°-360° | 13 | .011 |